CORROSION INHIBITION BY HENNA LEAVES EXTRACT IN INDUSTRIAL WASTEWATER

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STUDENT'S DECLARATION

I hereby declare that the work in this thesis is based on my original work except for quotations and citations which have been duly acknowledged. I also declare that it has not been previously or concurrently submitted for any other degree at Universiti Malaysia Pahang or any other institutions.

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ABSTRAK

Inhibitor korosi adalah sebatian kimia yang ditambah kepada air sisa industri untuk mengurangkan kadar kakisan. Ia boleh memperlahankan serangan kakisan asid ke arah tiub, paip gerudi dan sebarang logam lain yang dihubungkan dengan asid semasa rawatan. Walau bagaimanapun, kos menggunakan inhibitor kakisan adalah mahal. Oleh itu, penyelesaian masalah ini adalah dengan menggunakan ekstrak tumbuhan sebagai perencat kakisan. Kajian ini bertujuan untuk menentukan dos optimum inhibitor pada keluli dan kesan suhu dan masa terhadap keluli dalam 1M HCl. Kesan penghambatan kakisan ekstrak daun inai (*Lawsonia inermis*) pada keluli dalam 1 M HCl telah dikaji dengan kaedah penurunan berat keluli. Eksperimen dijalankan pada 25 ℃, 40 ℃, 50 ℃, 60 ℃, dan suhu bilik dengan kepekatan estrak daun inai yang berbeza. Masa rendaman adalah 4 minggu untuk mengira kecekapan perencatan. Kecekapan tertinggi adalah 6% yang berada pada kepekatan daun inai ialah 35g/L. Untuk kadar kakisan, pembacaan tidak sekata di mana pada 5g/L kepekatan, kadar kakisan berkurangan. Dos optimum daripada daun henna ekstrak untuk kecekapan perencat ialah 35g/L. Untuk kesan suhu, apabila suhu meningkat, kecekapan inhibitor juga meningkat. Ia boleh dibandingkan apabila konsentrasi perencat adalah 35g/L, kecekapan perencatan adalah lebih rendah (1.84%) pada 25 ℃ berbanding suhu pada 60 ℃ iaitu 6.29%. Untuk perbezaan masa, ia mempunyai bacaan kecekapan hambatan tertinggi pada minggu keempat. Ketika pada minggu keempat, kecekapan inhibisi adalah 6.29% manakala pada minggu pertama, kecekapan inhibisi adalah 4.08%. Bagi isotherm penjerapan, graf Langmuir menunjukkan bahawa penjerapan ekstrak daun inai (*Lawsonia inermis*) mematuhi isotherm adsorpsi Langmuir. Sebagai kesimpulan, daun Henna boleh digunakan untuk mengurangkan hakisan peralatan dalam air sisa industri. Ia juga mempunyai kecenderungan untuk menjadi inhibitor yang baik. Dengan menggunakan daun henna, ia dapat mengawal dan mengurangkan kakisan di mana ia dapat mengurangkan kos.

ABSTRACT

A corrosion inhibitor is a chemical compound which added to industrial wastewater in order to reduce the rate of corrosion. It can slows the attack of acid corrosion towards tubing, drill pipe and any other metals that contact with acid during treatment. However, the cost of using corrosion inhibitor is expensive. Therefore, the solution of this problem is by using plant extract as corrosion inhibitor. This study aims to determine the optimum dosage of inhibitor on mild steel in 1M HCl and the effect of temperature and contact time on mild steel in 1M HCl. Corrosion inhibition effect of Henna Leaves Extract (*Lawsonia inermis*) on mild steel in 1 M HCl has been investigated by weight loss method. Experiments will be conducted at 25℃, 40℃, 50℃, 60℃, and at room temperature with different concentration of henna leaves extract. The immersion time is 4 weeks to calculate the inhibition efficiency. The highest efficiency is 6% which is at the concentration of henna leaves is 35g/L. For rate of corrosion, the reading is unfactured where at 5g/L of concentration, the rate of corrosion is decreased. The optimum dosage of henna leaves extract for efficiency of inhibitor was 35g/L. As for the effect of temperature, when the temperature was increased, the inhibition efficiency also increased. It can be compared that when the concentration of inhibitor is 35g/L, the inhibition efficiency was lower (1.84%) at 25℃ compared to the temperature at 60℃ which is 6.29%. For the contact time, it have the highest inhibition efficiency reading at the fourth week. When at the fourth week, the inhibition efficiency is 6.29% while at the first week, the inhibition efficiency is 4.08%. For the adsorption isotherms, the Langmuir graph shows that the adsorption of henna leaves extract (*Lawsonia inermis*) obeys Langmuir adsorption isotherm. As a conclusion, Henna leaves can be used in reduce the corrosion of equipments in industrial wastewater. It also has the tendency to be a good inhibitor. By using henna leaves, it can control and reduce the corrosion where it can reduce the cost.

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LIST OF SYMBOLS

%	Percentage
°C	Degree Celcius
M	Molarity
mL	Millilitre
K	Kelvin
g/L	Gram per Litre
mg/L	Milligram per Litre

LIST OF ABBREVIATIONS

NACE	National Association of Corrosion Engineers
HCl	Hydrochloric Acid
SCC	Stress Corrosion Cracking
VCI	Volatile Corrosion Inhibitor

CHAPTER 1

INTRODUCTION

1.1 Preamble

Corrosion is a natural phenomenon where it happen in many situations. This is because it can happen when chemical reaction is reacted between metal, air and the surrounding environment. The process of corrosion is not only depends on the chemical properties of metal but it also influence the changes of mechanical behaviour and physical properties of the metal. The name of the reaction of corrosion process is reduction-oxidation (redox) reaction where some species of metal is required oxidized and some species is reduced. In industries, corroded metal causes major losses due to the wide application of metals (Arockiasamy *et al*., 2014).

There are three methods that used commonly in industry to control and protect the metal from corrosion. The methods are coating, cathodic protection and corrosion inhibitor. For coating, there are various types of coatings that are used in industrial waste which are physical barrier coatings, metallic coatings, non-metallic coatings and chemical conversional coatings. These coatings provide a barrier between the surface and the environment (Singh *et al*., 2012). Most of the steel pipes are highly corrosive nature of wastewater where the coatings are cracks and develop small pinholes. The other treatment that can prevent from corrosion is cathodic protection.

Cathodic protection is to control the corrosion of the piping and tanks where the system is been tested by National Association of Corrosion Engineers (NACE)-certified specialist (Camila *et al*., 2014). Corrosion inhibitor is a chemical compound where to decrease the rate of corrosion of material which are steel and metal. Inhibitors are act through the process of surface adsorption and its adsorption depends on the nature and

surface charges on the metal (Pavithra *et al.*, 2013). To prevent the access of corrosive substance to metal, the formation of coating is involved in the mechanism of corrosion inhibition. Inorganic inhibitors, which are mainly oxidizing agents, such as chromates, iodates, and tungstate act as anodic inhibitors and their metallic atoms are enclosed in the film improving its corrosion resistance. However, these compounds are very expensive (Kumar *et al*., 2018).

Although many of these tested compounds have high inhibition efficiency, the usage of them still undesired due to their adverse effect on human, environment, as well of their high cost. The increasing concern about these problems had attracted industries to replace it with more environmentally acceptable, readily available and renewable source for wide range of inhibitors which have rich source of ingredients and high inhibition efficiency.

1.2 Problem Statement

Corrosion is always happen in industrial wastewater equipments such as pipes, tanks and pumps. There are many solutions that have been discovered to reduce the corrosion in the equipments. The method that used to retard the process of corrosion is anticorrosive coatings. Inorganic pigments are usually added to coatings for long term performance where can release the corrosion inhibiting (Zulkifli *et al*., 2017).

Besides that, the method that used to prevent corrosion is cathodic protection system. Before install this system, an economic evaluation should be conduct where the cost of the system is low but it is difficult to quantify from the failures of equipment. However, they are giving effect to environment and health where it due to carcinogenic nature and toxic from the corrosion inhibitors. Umoren *et al*,. (2018), illustrated that nitrogen based organic inhibitors like amines and imidazolines or their salts are the most profitably used to occur the corrosion in internal pipelines. Due to their toxic nature, they are not environmentally friendly and it is very costly even though the inhibitors have good protection and stable in corrosive environments (Umoren *et al*,.2018).

Hence, to reduce the cost and the effect on environment and health, the cheaper and organic inhibitor have been found. The most common method that been used to prevent the corrosion in wastewater treatment plant are very difficult to qualify. Therefore, the aim of this research is to find the best inhibitor to prevent the corrosion of metal in wastewater treatment plant.

1.3 Objective of Study

There are two objectives for this research based on the problem statement. The following are the objectives:

i. To determine the optimum concentration of inhibitor

ii. To compare the effect of contact time and temperature of inhibitor

1.4 Scope of Study

This study carried out to study the optimum dosage of the inhibitor to prevent the corrosion and the effect of contact time and temperature of inhibitor on mild steel. Henna leaves have been collected from the person who have henna trees. Henna leaves extract was prepared at laboratory. HCl solution was prepared where this solution was presented as industrial wastewater. This study was focusing the effectiveness of henna leaves extract as the corrosion inhibitor to prevent the corrosion happen in industrial wastewater.

1.5 Significance of Study

This research was do the treatment which can prevent the corrosion of the equipments such as pipes, tanks and pumps. The inhibitor that used in this study is organic leaves. By using organic leaves, it can reduce cost, improve the efficiency, eco environmental and provide variation methods of the industrial wastewater. From this study, it become another alternative which can reduce the cost of conventional treatment. This study is to determine the efficiency of the inhibitor where it can prevent the metal from corrosion. End of this study, the method of lower cost and effectiveness of inhibitor is proposed. This treatment can be used widely by industrial management where it can control and reduce the corrosion of metal.

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